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## EUROPEAN PATENT APPLICATION

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⑪ Percutaneous stent and method for retrieval thereof.

⑫ A self-expanding stent (10) formed of stainless steel wire arranged in a closed zig-zag configuration includes an endless series of straight sections (13) joined at their ends by bends (14). The stent is compressible into a reduced diameter size for insertion into and removal from a body passageway. The bends of at least one end of the stent are formed into eyes (20) for connection with the eyes at one end of a similarly constructed stent to permit single-step introduction of several lengths of stent into the passageway. A stent can include a monofilament thread (40) passing through successive eyes at one end of the stent, the thread passing through each eye at least once and through some of the eyes a

second time. The trailing ends (40a, 40b) of the thread extend from the stent and outside the body passageway. The stent can be retrieved from the body passageway by threading a tube (70) over the free ends of the thread until the tube is adjacent the stent. The diameter at one end of the stent is reduced by pulling the free ends of the thread through the tube. A sheath (75) concentrically disposed over the tube is introduced into the body passageway and over the remaining length of the stent to further compress the stent for removal from the passageway.

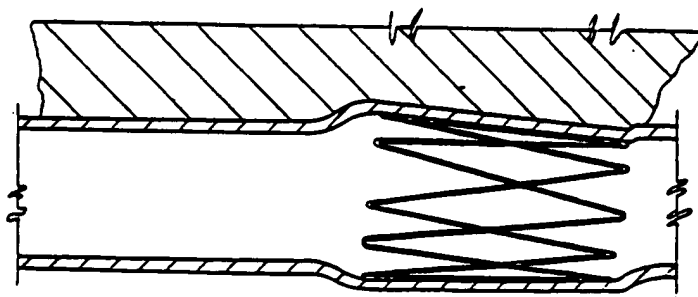


Fig.1  
PRIOR ART

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wherein the straight sections press against the walls of the passageway to maintain it open.

Another embodiment of the invention involves a self-expanding stent of closed zig-zag configuration having eyes at bends joining the straight sections of the stent. A monofilament thread is passed through each of the eyes at one end of the stent, once through each of the eyes in a 360° loop and then again 180° through some of the eyes. The trailing free ends of the monofilament leave the stent at opposite sides of the stent diameter and extend through an introducer sheath outside the body passageway. The monofilament can be tied externally to limit the expansion of the self-expanding stent within the body passageway.

The free ends of the monofilament can also be used to reduce the diameter of the stent to permit retrieval of the stent from the body passageway. Thus, in a method of the invention, a tube is threaded over the free ends of the monofilament and advanced along the passageway until the tube is adjacent the expanded stent. The free ends are then pulled thereby contracting the outer diameter of the stent until the diameter is approximately equal to the diameter of the tube. A sheath can then be introduced over the tube and over the reduced diameter portion of the stent to further collapse the remaining length of the stent. The entire assembly, including the tube, sheath, stent and monofilament can then be removed from the body passageway.

One object of the invention is to provide a self-expanding stent that permits the combination of several interlocked stents for insertion into a body passageway. Another object of the invention is to provide a method for removal of a self-expanding stent situated within a body passageway. Other objects and benefits of the present invention can be discerned from the following written description of the invention along with the accompanying drawings.

#### Brief Description of the Drawings

FIG. 1 is side cross-sectional view of a body passageway with a self-expanding wire stent of the prior art situated therein.

FIG. 2 is a view similar to FIG. 1 showing the use of several stents of the prior art within the body passageway.

FIG. 3 is a side elevational view of a preferred embodiment of the present invention.

FIG. 4 is an end elevational view of the structure of FIG. 3.

FIG. 5 is a side elevational view of another embodiment of the present invention.

FIG. 6 is a side elevational view of another

embodiment of the present invention.

FIG. 7A is a side elevational view of still another embodiment of the present invention shown in its expanded state.

FIG. 7B is a side elevational view of the structure of FIG. 7A shown with one end in its contracted state.

FIG. 8 is a sectional view of a body passageway showing a method of insertion of the self-expanding stent of the present invention.

FIG. 9 is a sectional view of the body passageway similar to FIG. 8 following insertion of the self-expanding stent.

FIG. 10A is a sectional view of the body passageway shown in FIG. 9 showing one step of a method of retrieval of the self-expanding stent of one embodiment of the present invention.

FIG. 10B is a view similar to FIG. 10A showing another step of the method of retrieval.

FIG. 10C is a view similar to FIG. 10B showing another step of the method of retrieval of the present invention.

#### Description of the Preferred Embodiment

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Referring now more particularly to the drawings, there is illustrated in FIGS. 3-4 a side elevation of a preferred embodiment of the percutaneous stent 10 which is formed from a length 11 of stainless steel wire formed in a closed zig-zag configuration. The ends of the wire are closed by a sleeve 12 which is welded or tightly squeezed against the ends of the wire to produce a continuous or endless configuration. The length 11 of wire is arranged in a number of side-by-side straight sections 13. Adjacent straight sections 13 of the stents are adjoined by cusps 14.

Up to this point, the stent 10 of the present invention is, in most respects, similar to the Z-stent described in U.S. Patent No. 4,580,568, which description is incorporated herein by reference. In particular, the specific embodiment of the invention includes the wire 11 which is of stainless steel having a 0.018 inch outer diameter. The cusps 14, that is the joint between adjacent straight sections 13, generally circumscribes a radius of no more

be disposed to prevent any pinching or tugging of the filament while the sheath 60 is being removed. Once the sheath is removed, the pusher 61 can also be removed so that the stent 50 remains in position within the body passageway as shown in FIG. 9. The monofilament 56 trails the stent and passes outside the body as described above.

In certain medical operations, the stent 50 need only be positioned temporarily within the body passageway. Thus, in another method of the present invention, illustrated with reference to FIGS. 10A-10C, the stent 50 is retrieved from the body passageway and removed. In the method of this embodiment, a tube 70 is threaded over the free ends of the monofilament 56 and inserted into the body passageway along the monofilament 56 until it is adjacent the implanted stent 50, as shown in FIG. 10A. Once the tube 70 is positioned directly adjacent the stent 50, the free ends of the monofilament 56 can be pulled through the tube 70, thereby compressing or contracting one end of the stent 50 to a reduced diameter, as shown in FIG. 10B. With the end of the stent 50 thus compressed, a sheath 75 can be introduced into the body passageway over the tube 70, as shown in FIG. 10C. The sheath 75 has an inner diameter larger than the reduced diameter of the end of the stent 50. The sheath 75 is continually conveyed into the body passageway over the tube 70 until it contacts and compresses the remaining length of the self-expanding stent 50. Once the sheath 75 completely covers or shrouds the stent 50, that is when the stent 50 is disposed entirely within the sheath 75, the entire assembly can be removed from the body passageway. In the preferred embodiment of the present method, the tube 70 and sheath 75 are composed of medical grade plastic, such as an 8-polyethylene tubing.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiments have been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

#### Claims

1. A stent assembly comprising:  
a first wire formed into a closed zig-zag configuration including;  
an endless series of straight sections having opposite ends, said straight sections being joined by bends at said opposite ends to form a stent;  
a set of eyes formed at several of said bends at one of said opposite ends; and

a thread passing through successive ones of said set of eyes, said thread including a pair of free ends trailing from said stent;

wherein said stent is resiliently contractable into a smaller first shape for conveyance through a body passageway; and

wherein said stent is resiliently expandable into a second shape in which the straight sections press against the walls of the body passageway.

2. The stent assembly of claim 1, wherein:  
said second shape of said stent includes a circumference at said one of said opposite ends, said set of eyes being situated at said circumference; and  
said thread passes through successive eyes at least 360° around said circumference.

3. The stent assembly of claim 2, wherein said thread passes through successive eyes approximately 540° around said circumference.

4. The stent assembly of claim 1, wherein said free ends are sufficiently long to extend outside the body passageway when said stent is situated within the passageway.

5. The stent assembly of claim 1, further comprising;

a second wire formed into a closed zig-zag configuration including;

a second endless series of straight sections having opposite ends, said straight sections being joined by bends at said opposite ends to form a second stent;

a second set of eyes formed at several of said bends at one of said opposite ends;

wherein said second stent is resiliently contractable into a smaller first shape for conveyance through a body passageway;

wherein said second stent is resiliently expandable into a second shape in which the straight sections press against the walls of the body passageway; and

wherein said second set of eyes of said second wire are engaged about said first wire at one of said opposite ends.

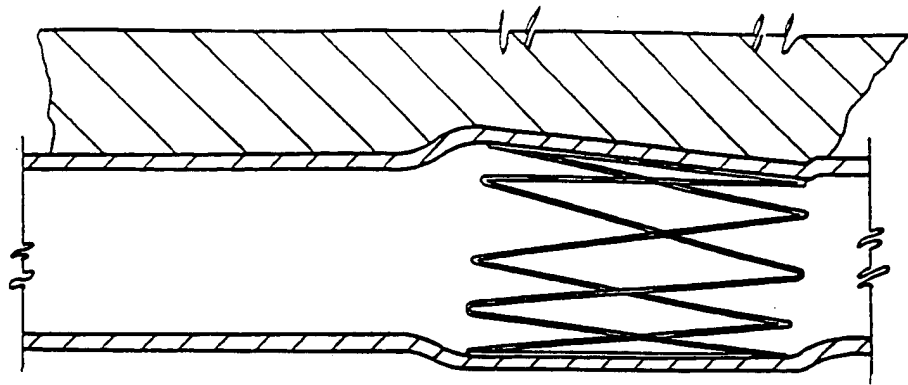
6. The stent assembly of claim 5, wherein:  
said first wire includes a third set of eyes formed at several bends at the other of said opposite ends of said first wire; and

said second set of eyes of said second wire are interengaged with said third set of eyes.

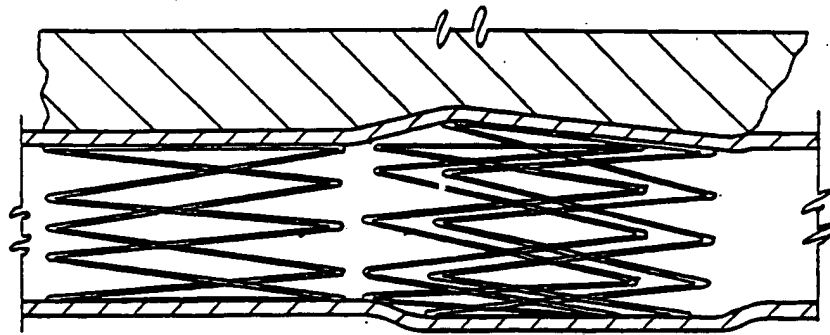
7. A method for combining a first and second self-expanding stent to form a stent assembly for insertion into a body passageway comprising the steps of:

forming a first stent from a continuous first length of wire formed into a closed zig-zag configuration having an endless series of straight sections joined at their ends by a plurality of bends;

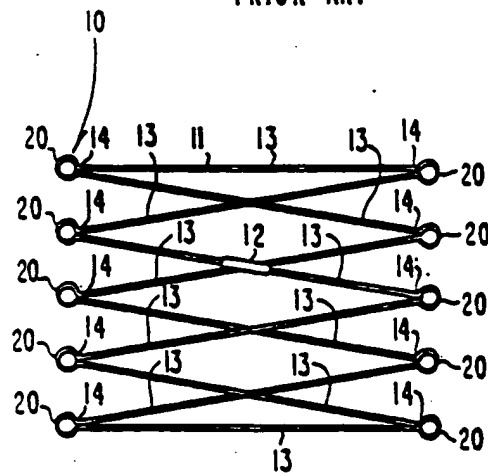
forming a second stent from a continuous second length of wire formed into a closed zig-zag configuration



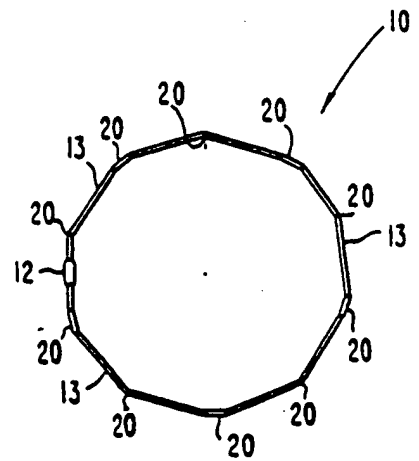
**Fig.1**  
PRIOR ART



**Fig.2**  
PRIOR ART



**Fig.3**



**Fig.4**

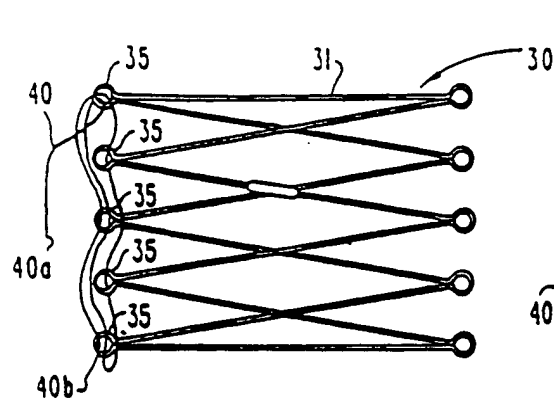


Fig. 7A

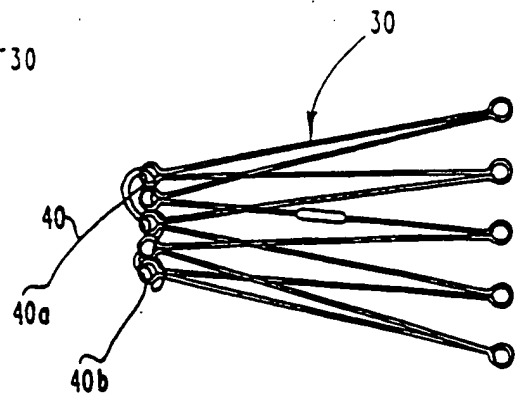


Fig. 7B

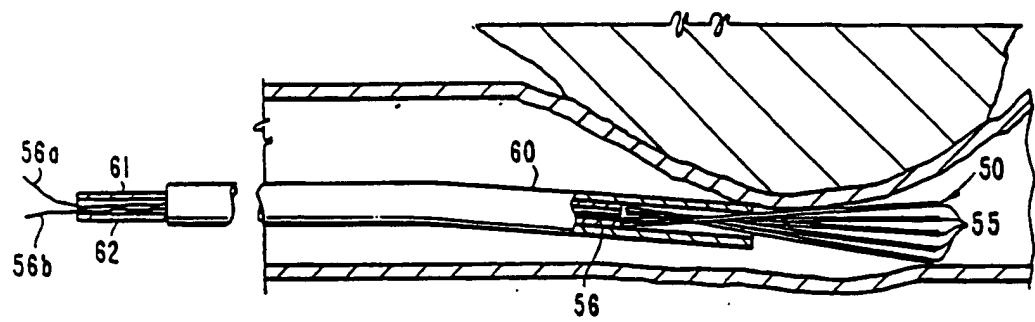


Fig. 8

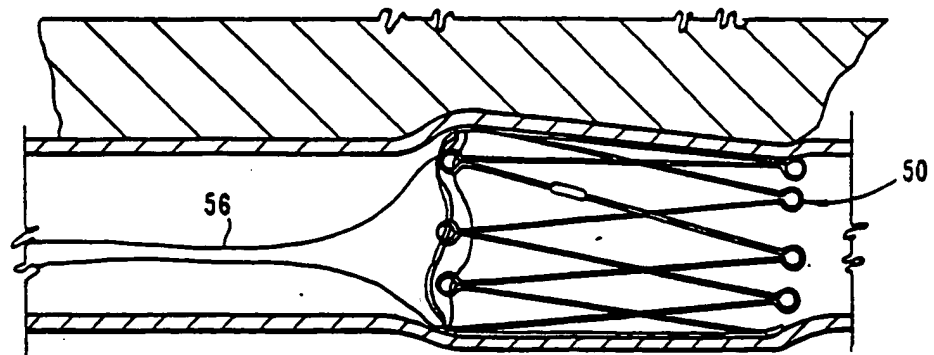


Fig. 9



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# EUROPEAN SEARCH REPORT

Application Number

## DOCUMENTS CONSIDERED TO BE RELEVANT

EP 90300542.9

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl. 5)
D,X	<u>US - A - 4 580 568</u> (GIANTURCO) * Totality; especially claim 1; fig. 1-10 *	1	A 61 M 29/00 A 61 F 2/02
A	<u>US - A - 4 830 003</u> (WOLFF et al.) * Claim 1; fig. 1-11 *	1	
A	<u>US - A - 4 739 762</u> (PALMAZ) * Claim 1; fig. 1-4 *	1	
A	<u>GB - A - 1 205 743</u> (NATIONAL RESEARCH) * Claim 1; fig. 1,4-7 *	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl. 5)
			A 61 M A 61 F A 61 B
The present search report has been drawn up for all claims.			

Place of search

Date of completion of the search

Examiner

VIENNA

19-12-1990

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### CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone  
A : particularly relevant if combined with another document of the same category  
A : technological background  
O : non-written disclosure  
P : intermediate document

1 : theory or principle underlying the invention  
E : earlier patent document, but published on, or after the filing date  
D : document cited in the application  
I : document cited for other reasons  
S : member of the same patent family, corresponding document